GE Corporate Research and Development

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TO: Steve Wax
Harold Guard
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Director, Naval Research Laboratory
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Enclosed is the DARPA R&D Status Report for July through September 1997, Contract No. N00014-96-C-0145.

If you have any questions, please call me.

Sincerely,

J.A. Cella, Manager
Silicone Technology Program

/pn
Enclosure

cc: B.J. Malloy

DARPA R&D Status Report

DARPA Order No.:

Program Code No.:

Contractor: General Electric Corporate Research and Development

Contract Amount: $2,582,405

Contract No.: N00014-96-C0145

Effective Date of Contract: June 26, 1996

Expiration of Contract: June 30, 2000

Principal Investigator: James A. Cella

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Short Title of Work: Non-Toxic, Self Cleaning Silicone Fouling Release Coatings

Reporting Period: July through September 1997

Description of Progress:

Task 1: Design, Synthesis and Testing of Foul Release Paints With Improved Antifouling and Release Properties

Task 1.1: Design, Synthesis and Testing of Foul Release Paints (GE-CRD)

Attempts to microencapsulate silicone oils for enhanced fouling release coatings with thermoset wall structures were unsuccessful: Microcapsule filled coatings failed abrasion resistance tests and had mediocre fouling release properties, despite having controlled release rates. Microcapsules with an alternative gel cap wall structure have been obtained from Cannon Chemical Co. Q-panels have been prepared in which the gel caps were incorporated into RTV11 at 10% loading and in the J501 tiecoat at 10% loading and have been deployed at FIT for foul release testing. Panels have also been sent to FIT in which capsicum has been incorporated into RTV11.

Task 1.1.1: Quantitative Foul Release Performance of New Materials (FIT)

Two instrumented foils that can measure the skin friction drag forces on 10" x 12"panels are now in operation and calibration trials using known surfaces and shapes are being completed. Thirteen panels for hydrodynamic testing were prepared, one for each of the downselected formulation and sent to FIT for testing.

A total of 127 panels has been placed in test at FIT since the commencement of the program. Barnacle adhesion measurements and water jet data have been collected on most of the panels.

Task 1.1.2: Field Exposure Testing (Bridger Scientific)

The four preliminary foul release coatings have been exposed for approximately 7 months at two utility locations. An additional set of panels was deployed at an alternate site in July, 1997. The performance ranking, with respect to estimated percent coverage and foul release/adhesion, is consistent between all locations. This is of particular interest since the test site provides exposure to a broad range of salinities. Replicates test panels in a series of thirteen downselected coatings were also deployed in July 1997. All have been examined monthly for fouling coverage and tested for foul release and adhesion. The best performers and worst performers have been identified.

Task 1.2: Validation Testing (NSWC, University of Hawaii)

A set of downselected composition was deployed by the University of Hawaii in July 1997. Waterjet measurements and *hydroides elegans* adhesion values have been obtained. The panel matrix clearly showed compositions to which *hydroides elegans* did not attach and compositions to which they adhered strongly.

Task 2: Optimize Coating Physical and Application Properties

Task 2.1: Physical Property Optimization (GE)

Physical property data for all downselected compositions has been obtained. Oil incorporation at a 10% loading did not compromise the physical properties of the coatings.

Task 2.1.1: Cleanability of Foul-Release Coatings (SUNY Buffalo)

The downselected panels were prepared for pre-exposure characterization and immersion at Dunkirk and Medina site. "A" and "B" replicates of each coating were abraded using the underwater brush unit. Panels were deployed on July 23, 1997. Water lance tests demonstrated that the downselected panels showed differences in slimes and silt removal. On a third set of panels, average depth of wear, surface residue and contact angles were measured as a function of brush abrasion tests.

Task 2.2: Field Demonstrations (NSWC)

In August 1997, during Refit #33 at TRF, Bangor, three silicone-based foul release duplex systems were applied on the hull of the USS Nevada (SSBN-733). All of the coatings contained an oil at 10% loading. Each of the three systems was applied to a 100 square foot area. There were no application issues with regard to the silicone topcoats.

Task 2.3: Coating Application Development (GE)

Prior to the patch tests at TRF, all three silicone coatings were evaluated for sprayability.
No issues were encountered.

Task 3: Environmental Impact and Toxicological Testing

Task 3.2: Environmental Impact (GE)

The GE/Navy Duplex system includes a topcoat comprised of crosslinked RTV containing silicone oil additives. Studies have been underway to determine the rate that these silicone oil additives leach out of the RTV in both fresh water and marine environments. These studies have been performed using ^{14}C-labeled oils and measuring the amount of ^{14}C in the water and sediment over time using fish tanks.

After five months in both fresh water and salt water tanks, less than 0.2% and 0.04% of a ^{14}C-labeled polydimethylsiloxane (PDMS) was detected in the water and sediment, respectively. This indicates that PDMS, a silicone oil compatible with RTV, is expected to have a long lifetime (several years) in silicone foul-release paints.

Similarly, less than 0.4% and 0.04% of a ^{14}C-labeled polydimethyldiphenylsiloxane (e.g. SF 1154) was detected in water and sediment, respectively, after four months in both fresh water and salt water. The data indicate that SF 1154, an oil less compatible with RTV, will also have a long lifetime in the RTV topcoat.

A third ^{14}C-labeled oil, a carbinol terminated PDMS, has recently been applied to metal coupons as an additive in RTV. The metal coupons have been added to both fresh water and marine fish tanks and the fate of the oil will be monitored over time.

Task 3.2: Toxicological Studies (NSWC, NCCOSC)

Eight coatings were originally received by NCCOSC from General Electric for toxicity testing using standard EPA bioassays. Currently six of the eight coatings have undergone 4 day acute tests with mysid shrimp. LC50's were generated for these coatings between 150-300% leachate solutions. LC50 represents the lethal concentration which kills 50% of the tested population. To date for day acute algal tests were also conducted on four of the eight coatings. The algae tend to be more sensitive than the mysids as IC50's were lower in 2 of the 4 coatings tested. IC50 represents the inhibition concentration which reduces or inhibits algae growth by 50%.

Change in Key Personnel:

None.

Summary of Substantive Information Derived from Special Events:

Kathryn Truby attended the AFOSF review on September 17, 1997 and presented an overview of the DARPA sponsored program.

Problems Encountered and/or Anticipated:

None.

Action Required by the Government:

None.

Fiscal Status:

(1) **Project Cost:**	$952,633
(2) **Cost Share:**	(230,395)
(3) **Net to ONR/DARPA:**	$722,238